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Pasadena, California

Atmospheric Infrared Sounder

7.5-YEARS OF AIRS Mid Tropospheric CO_2

Sept 2002-March 2010

Validation & Applications

Update

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X. Jiang (U. Houston), Y.L. Yung (Caltech)
S. C. Wofsy (Harvard) and S. A. Vay (LRC)

AIRS Science Team Meeting

Caltech

Pasadena California

April 21 - 23, 2010

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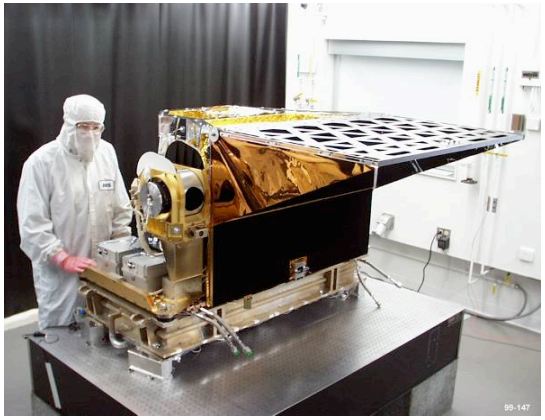
Atmospheric Infrared Sounder

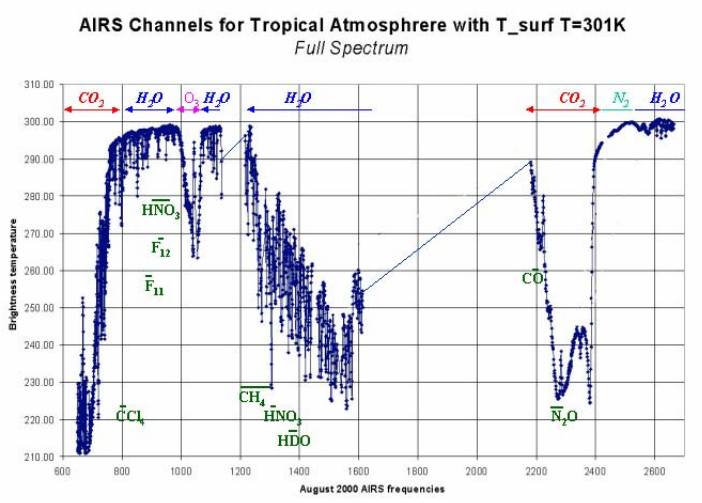
The Atmospheric Infrared Sounder on NASA's EOS Aqua Spacecraft

AIRS

- AIRS Characteristics
- Launched: May 4, 2002
- Orbit: 705 km, 1:30pm, Sun Synch
- IFOV : 1.1° x 0.6°
  (13.5 km x 7.4 km)
- Scan Range: ±49.5°
- Full Aperture OBC Blackbody, ε > 0.998
- Full Aperture Space View
- Solid State Grating Spectrometer
  - IR Spectral Range:
    3.74-4.61 μm, 6.2-8.22 μm,
    8.8-15.4 μm
  - IR Spectral Resolution:
    ≈ 1200 (λ/Δλ)
  - # IR Channels: 2378 IR
- VIS Channels: 4
- Mass: 177Kg,
  Power: 256 Watts,
  Life: 5 years (7 years goal)



AIRS Spectra



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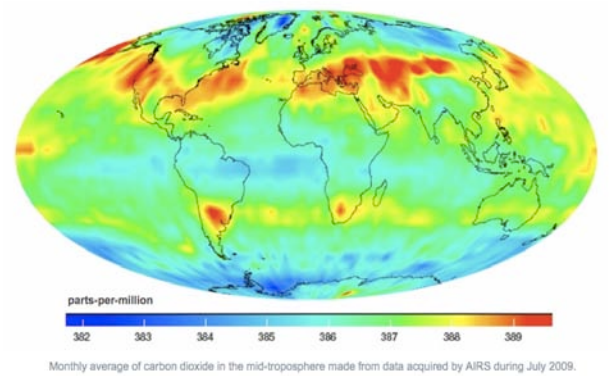
Release of AIRS CO2 Data Products
http://airs.jpl.nasa.gov/AIRS_CO2_Data

AIRS Level 2 and Level 3 Mid-Tropospheric CO2 Data Release



Monthly average of carbon dioxide in the mid-troposphere made from data acquired by AIRS during July 2009.

September 2002 - February 2010

Latitude Range: 60°S to 90°N

Level 2
- includes averaging kernels
- nadir resolution: 100km x 100km

Level 3
- spatial grid: 2° x 2.5° (lat/lon)
- time periods: 1d,8d,calendar month

Contact: Edward.T.Olsen@jpl.nasa.gov
phone: 818-354-7604

Access to AIRS Tropospheric CO2 Product Files

The AIRS CO2 product files may be freely downloaded from the Goddard Earth Sciences (GES) Data and Information Services Center (DISC). The links listed below will give you access to all the AIRS carbon dioxide data products.

The URL providing links to all methods of access to AIRS Data Products:

http://disc.sci.gsfc.nasa.gov/AIRS/data-holdings

Links on this web page may be used to search for and subset all AIRS data products by type, geospatial location, and time and to download them via ftp or directly via links on web pages.

URLs for access via Mirador to the Level 2 (standard, support) CO2 Data Products:

http://mirador.gsfc.nasa.gov/cgi-bin/mirador/collectionlist.pl?keyword=airx2stc
http://mirador.gsfc.nasa.gov/cgi-bin/mirador/collectionlist.pl?keyword=airx2spc

URLs for access via Mirador to the Level 3 CO2 (daily, 8-day, monthly) Data Products:

http://mirador.gsfc.nasa.gov/cgi-bin/mirador/collectionlist.pl?keyword=airx3c2d
http://mirador.gsfc.nasa.gov/cgi-bin/mirador/collectionlist.pl?keyword=airx3c28
http://mirador.gsfc.nasa.gov/cgi-bin/mirador/collectionlist.pl?keyword=airx3c2m

Corresponding URLs for access via the Web Portals:

http://disc.sci.gsfc.nasa.gov/AIRS/data-holdings/by-data-product/airsL2_Stc
http://disc.sci.gsfc.nasa.gov/AIRS/data-holdings/by-data-product/airsL2_Spc
http://disc.sci.gsfc.nasa.gov/AIRS/data-holdings/by-data-product/AIRX3C2D
http://disc.sci.gsfc.nasa.gov/AIRS/data-holdings/by-data-product/AIRX3C28
http://disc.sci.gsfc.nasa.gov/AIRS/data-holdings/by-data-product/AIRX3C2M

The sample L2 swath and L3 grid data readers provided with the AIRS V5 documentation package are available at the URL:

http://disc.sci.gsfc.nasa.gov/AIRS/documentation

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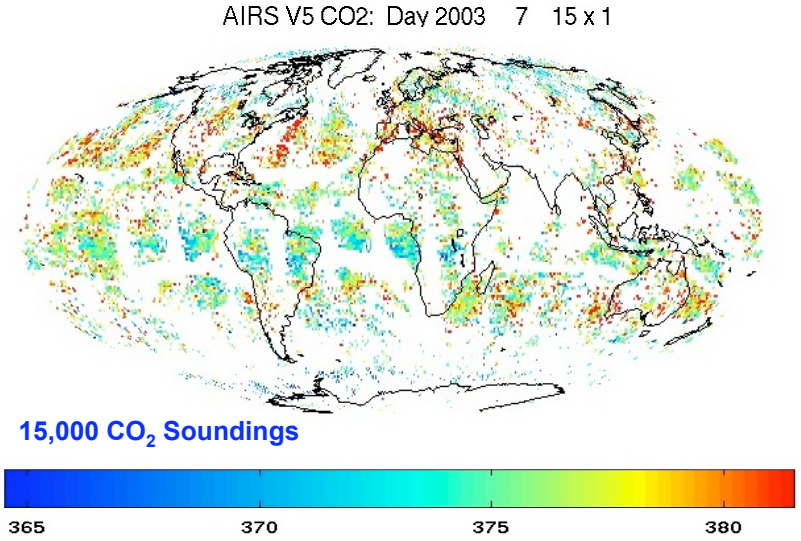
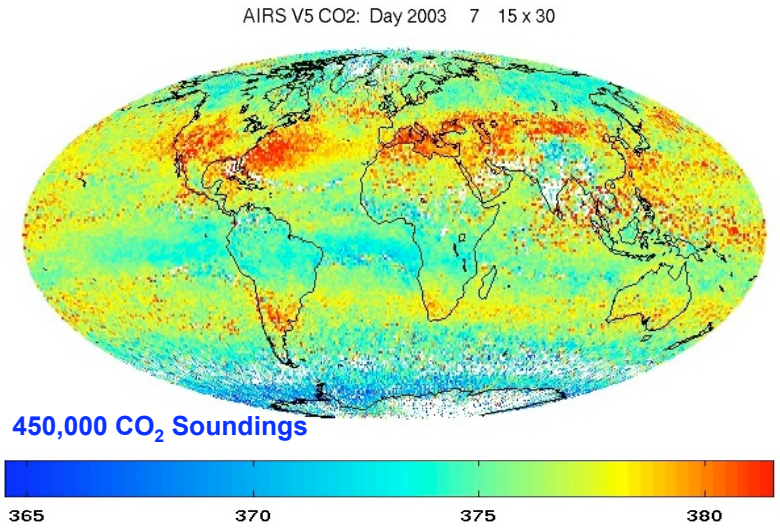
Global Yield of AIRS Level 2 Mid-Tropospheric CO_2

AIRS Daily CO_2 Yield 1°x1° Spatial Resolution



AIRS Monthly CO_2 Yield 1°x1° Spatial Resolution



AIRS Level 2 Mid-Tropospheric CO_2 retrieval yield is controlled by requirement for highest quality temperature and water vapor AIRS Level 2 products in 2x2 array of adjacent FOVs

Day/Night, Pole-to-Pole, Land/Ocean/Ice, Cloudy/Clear

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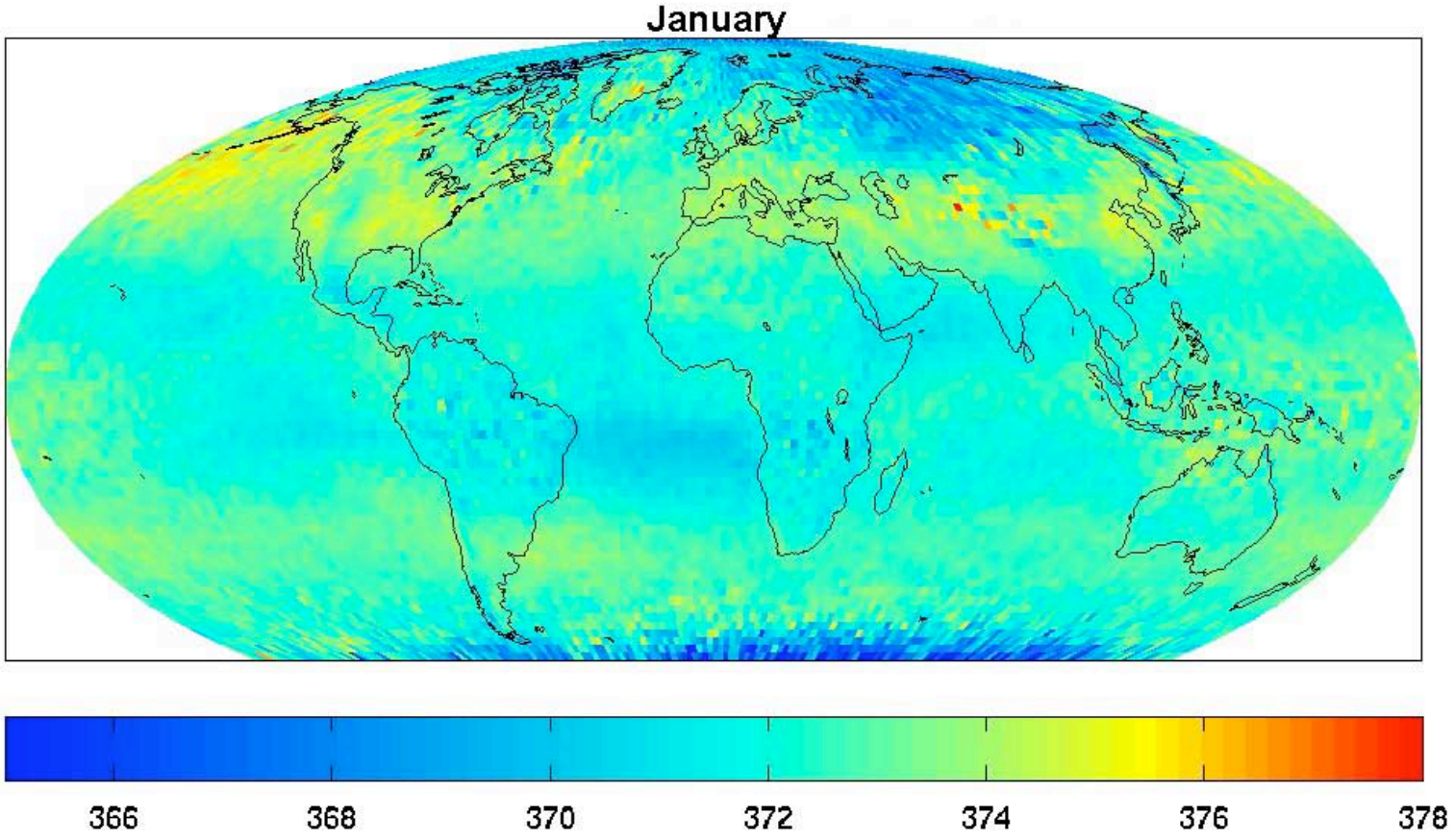
Monthly Average Detrended Mid-Tropospheric CO_2



Monthly Average Data binned at 2°x2° spanning January 2003 to December 2009 detrended at 2.1 ppm/yr, then individual months (all Jans, all Febs, etc) averaged

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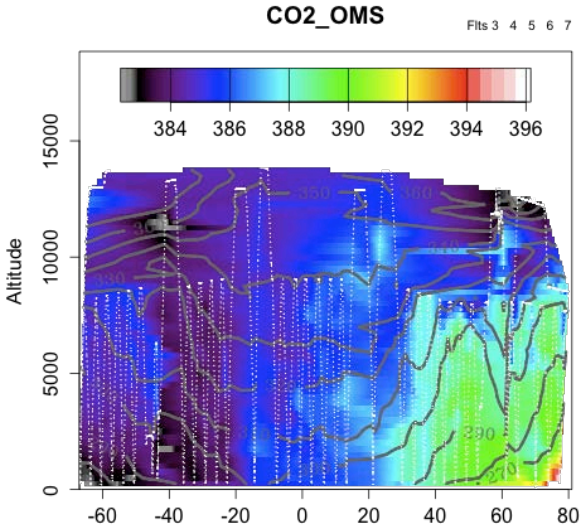
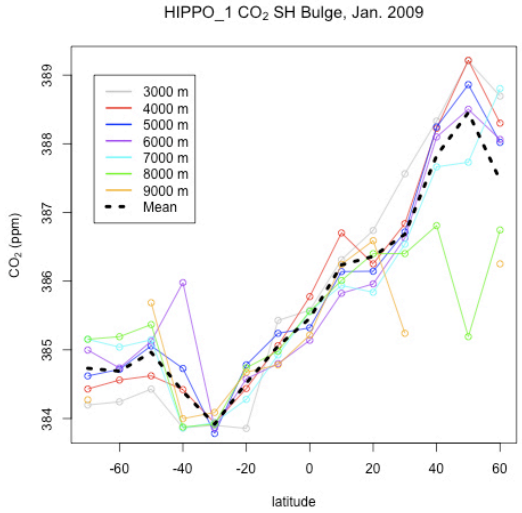
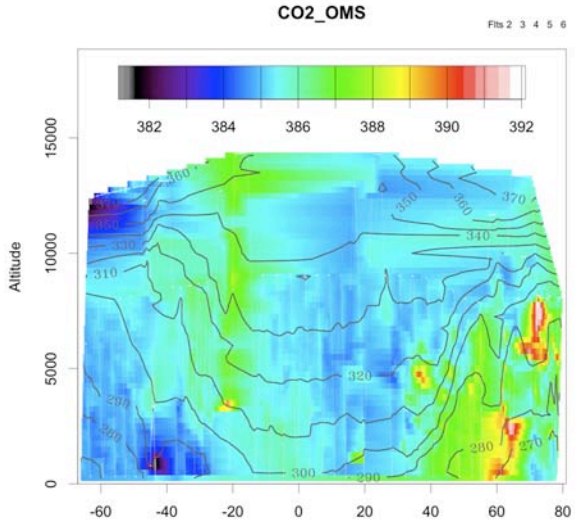


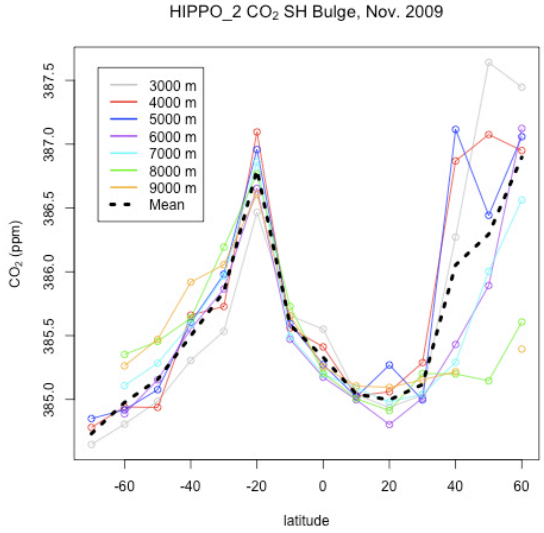


HIPPO_1

Xsects along the Dateline

Jan 2009





HIPPO_2

Xsects along the Dateline

Nov 2009

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Validation and Comparisons with In Situ Measurements

- Aircraft profiles of CO_2 concentration
  - ➔ Direct validation of satellite retrievals

- CONTRAIL CO_2 samples at altitudes 10.5 km to 12.5 km
  - ➔ Validate amplitude, phase of seasonal variations and interannual trends as function of latitude

- TCCON daytime cloud-free column average CO_2 measurements
  - ➔ Validate phase of seasonal variations and interannual trends; allows estimation of drawdown in PBL

- Surface stations
  - ➔ Estimate differences between free troposphere and planetary boundary layer; compare interannual trends

60°S-90°N RMS agreement is within 2 ppm

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AIRS CO_2 Validation via Aircraft CO_2 Profiles

Aircraft Profiles are Best Available Validation

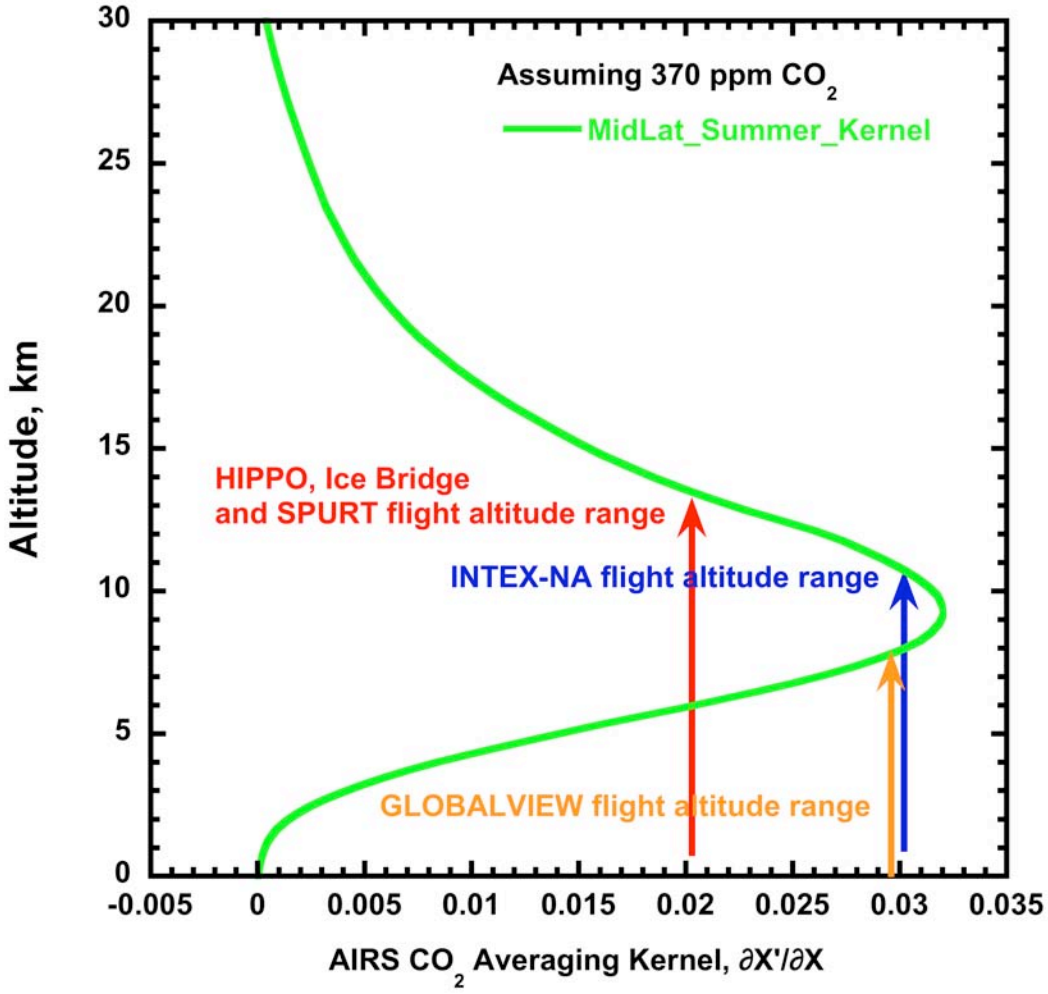
- Convolve the aircraft profiles with the AIRS sensitivity functions to arrive at a single number to compare to the AIRS result.

- HIPPO flights in January 2009:
- Ice Bridge flights Oct/Nov 2009:
  - Maximum Altitude: 14.5 km
  - Pressure Range: 1000 to 130 hPa

- SPURT flights in April 2003:
  - Maximum Altitude: 13.7 km
  - Pressure Range: 850 to 140 hPa

- INTEX-NA flights in July 2004:
  - Maximum Altitude: 10.7 km
  - Pressure Range: 850 to 240 hPa

- GLOBALVIEW flights (multi-year, many):
  - Maximum Altitude: 8 km (usually 6 km)
  - Pressure Range: surface to 360 hPa



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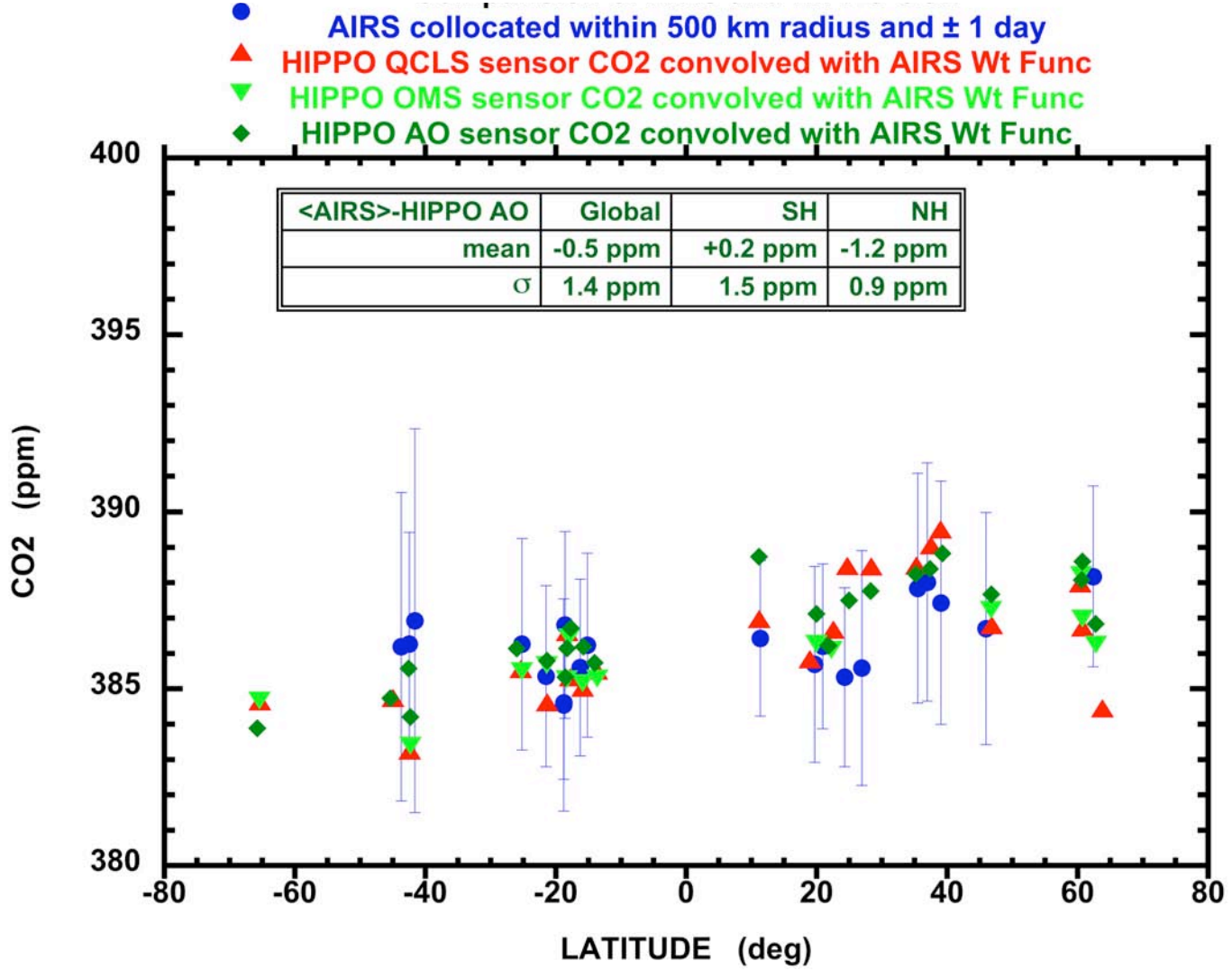
Comparison of Collocated AIRS CO_2 Retrievals with January 2009 HIPPO Data for profiles ranging from near surface to p < 200 hPa



HIPPO CO2 vertical profile data courtesy of Steven C. Wofsy

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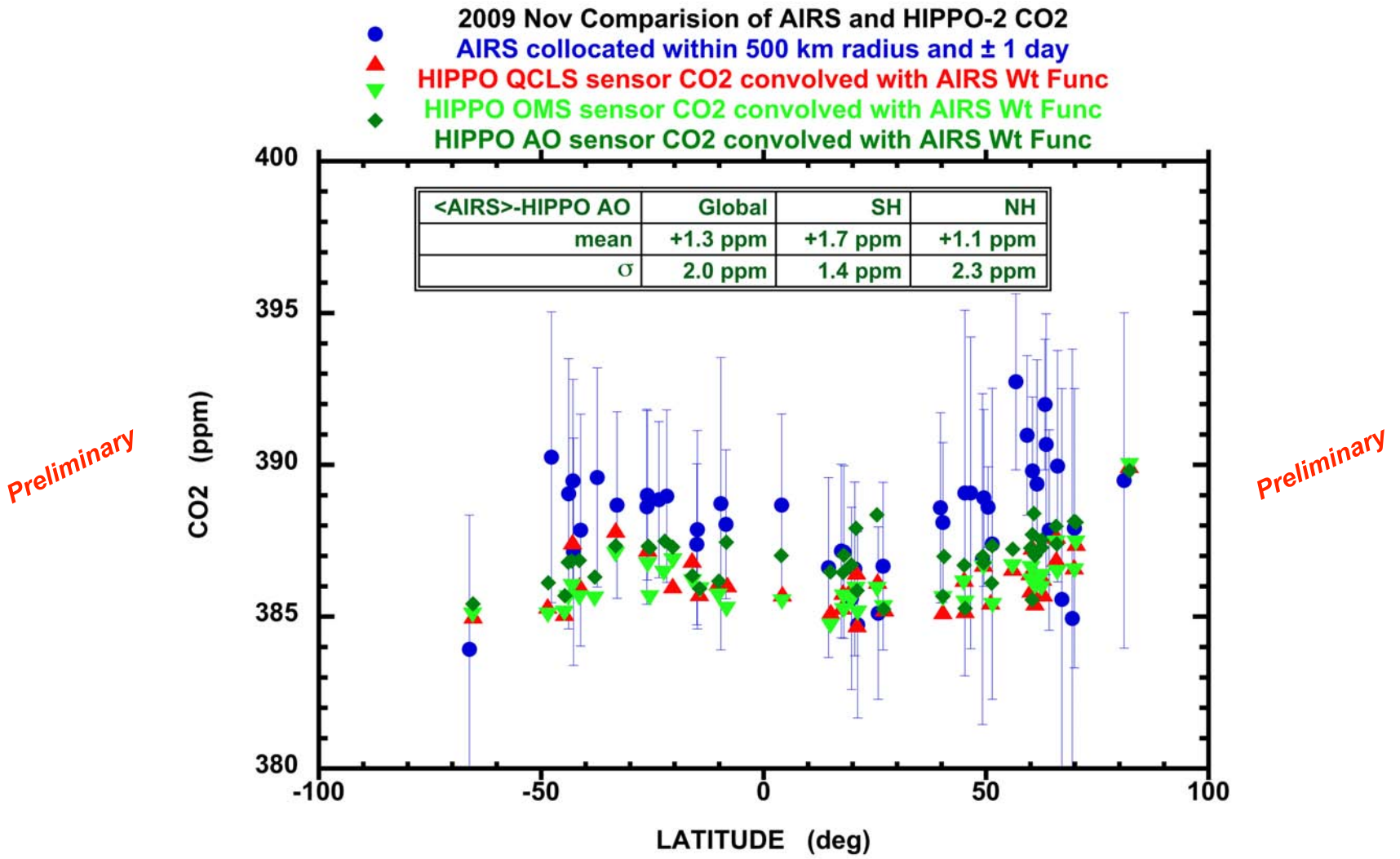
Comparison of Collocated AIRS CO_2 Retrievals with January 2009 HIPPO Data for profiles ranging from near surface to p < 200 hPa



Preliminary

Preliminary

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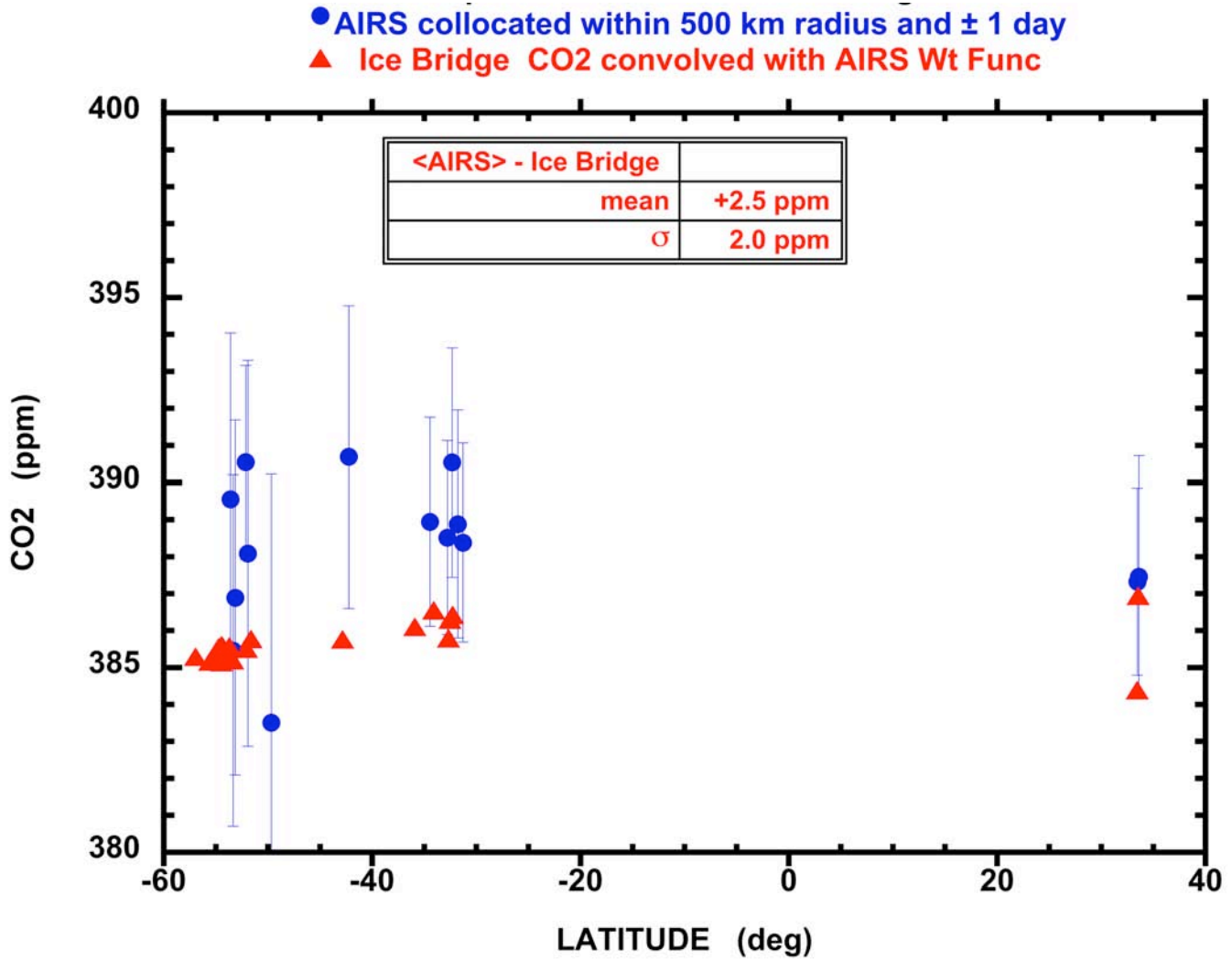
Comparison of Collocated AIRS CO_2 Retrievals with October-November 2009 Ice Bridge Data

for profiles ranging from near surface to p ≈ 200 hPa

ARCTAS in process

Preliminary



Preliminary

Ice Bridge CO2 vertical profile data courtesy of Stephanie A. Vay

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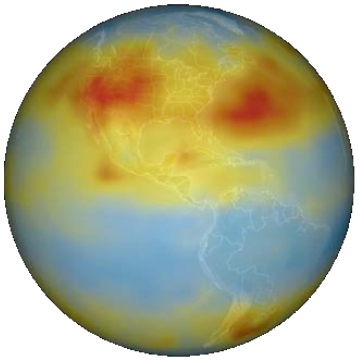
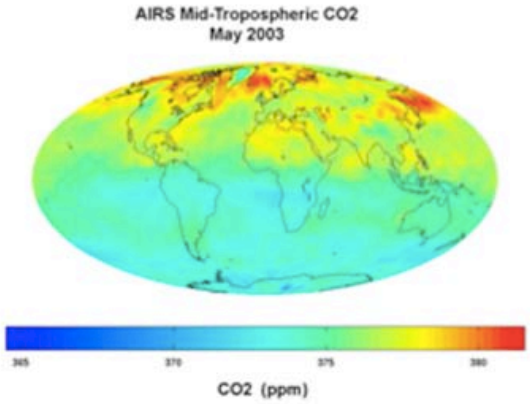
7-Years of AIRS Mid-Trop CO_2

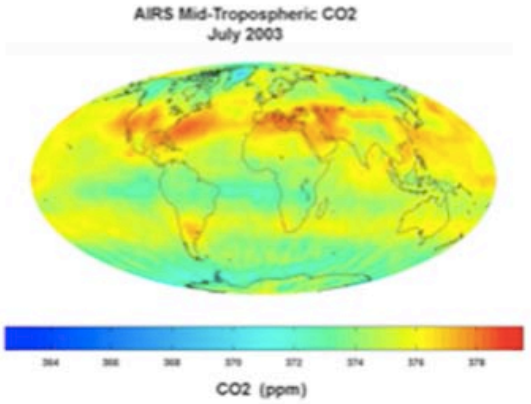
What have we Observed/Learned?



1. CO_2 is <u>NOT</u> Horizontally Well Mixed in the Trop.
   - Driven by Weather Patterns (Jet Stream)

2. Complexity of the Southern Hemisphere Carbon Cycle
   - Calls for Expanded Validation Efforts and Analysis





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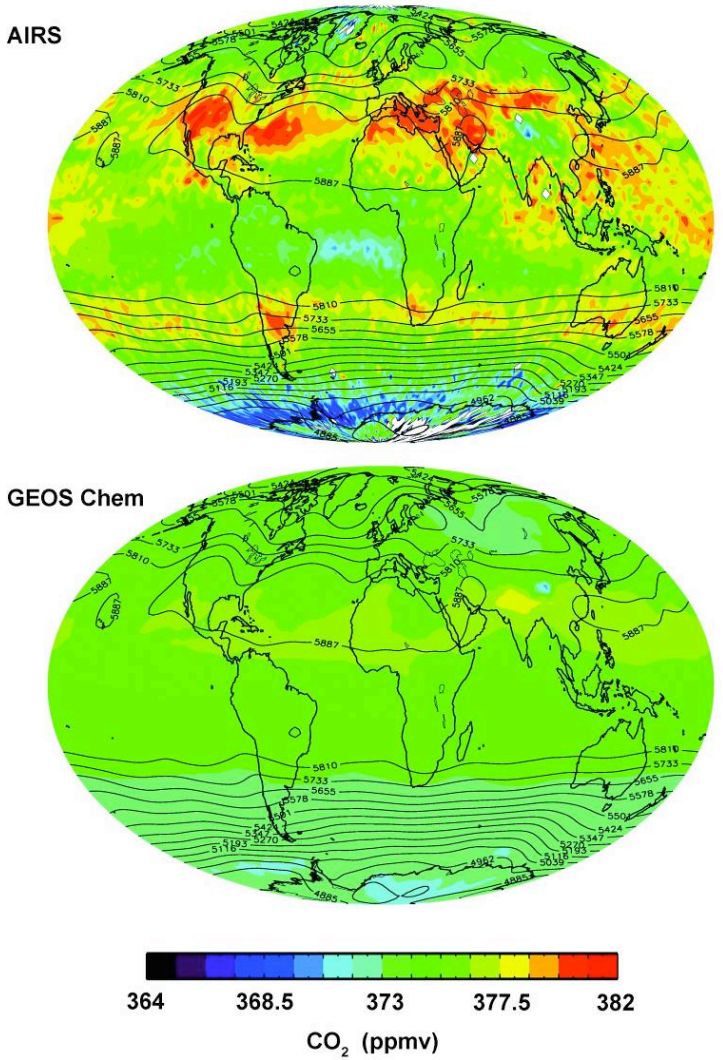
AIRS CO_2 Compared to Models

Current Models of Global Distribution of CO_2 do not capture observed spatial and temporal variability



Chahine, M. T., L. Chen, P. Dimotakis, X. Jiang, Q. Li, E. T. Olsen, T. Pagano, J. Randerson, and Y. L. Yung (2008), Satellite remote sounding of mid-tropospheric CO2, ***Geophys. Res. Lett., 35, L17807, doi: 10.1029/2008GL035022.***

7-Years of AIRS Mid-Trop CO_2

What Processes have we Observed/ Studied?

1. Vegetation uptake over Park Falls

2. Seasonal Cycle and Trend well captured in AIRS Data
   (Comparison with Independent in-situ Aircraft Data)

3. Intraseasonal and Interannual Variability
   (Semi- annual Oscillation in AIRS CO_2; Influence of Polar Vortex on AIRS CO_2)

4. Stratospheric-Tropospheric exchange
   (SSW Event - increased O_3 & decreased CO_2 in the Troposphere)

5. Influence of ENSO on CO_2 during El Nino Event
   (More CO_2 in the Central Pacific and Less in the Western Pacific)

6. Direct Assimilation of AIRS CO_2 Retrievals using the Ensemble Kalman Filter (EnKF)

Thank You